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HEAT INSULATION AND ENERGY-SAVING CONSTRUCTION MATERIALS

Matyokubov Bobur Polatovich, *Lecturer;*
Zoyirova Elmira Bakhriddinovna, *Student;*
Samarkand State Architecture and Construction
University named after Mirzo Ulugbek (SamSACU), Uzbekistan.
pulatovich93@gmail.com

Abstract: This article highlights the significance of heat insulation and energy-saving materials in modern construction. Preventing heat loss is a crucial factor in increasing energy efficiency and ensuring environmental sustainability in the construction industry. Research findings indicate that materials such as polyurethane foam, mineral wool, extruded polystyrene (XPS), and vacuum panels exhibit high insulation properties. This paper analyzes the characteristics of these materials, their evaluation methods, and their effectiveness in construction.

Keywords: Heat insulation, energy-saving materials, polyurethane foam, mineral wool, XPS, vacuum panels, construction efficiency.

Introduction: Energy efficiency and heat insulation play a significant role in modern construction. Preventing heat loss in buildings not only ensures energy savings but also supports environmental sustainability. The thermal conductivity coefficient of construction materials is one of the primary factors determining their effectiveness. This article examines energy-saving construction materials and their role in heat insulation.

Methods

The following methods are used to evaluate the heat insulation properties of construction materials:

1. **Determining thermal conductivity** – The λ (lambda) coefficient of construction materials is measured through specialized laboratory tests.
2. **Testing and experiments** – Materials are tested under real conditions to assess their heat retention properties.
3. **Composite material research** – The efficiency of multilayer materials is compared, and innovative approaches are proposed.
4. **Energy efficiency analysis** – The heat-saving characteristics of construction materials are evaluated based on their impact on the overall energy consumption of buildings.

Results:

The conducted studies demonstrate that the use of high-performance thermal insulation materials significantly reduces the energy consumption of buildings. The following materials have been identified as particularly effective:

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1. **Polyurethane foam** – With low density, it provides excellent thermal insulation and is actively used for insulating industrial, public, and residential buildings.Polyurethane foam has proven to be one of the best insulation materials, especially when applied by spraying. This technology offers several advantages. First, compared to other insulation methods, spray application saves considerable time and effort. Second, the applied foam fills cracks and gaps, forming a monolithic coating layer. Additionally, polyurethane foam has low thermal conductivity, preventing heat loss.

Figure 1: Polyurethane foam

2. Mineral wool – Environmentally safe with high heat retention capacity.

Mineral wool, which fully meets international standards, is a valuable thermal insulation material for both industrial and residential buildings. It is produced using natural raw materials, including quartz, and does not cause allergic reactions or skin irritation.

Mineral wool is completely safe for use in bedrooms. It not only provides long-term heat and sound insulation but also reduces energy costs over many years. Due to its high efficiency, it is widely used in gas and hot water pipelines, as well as household ventilation systems.

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Figure 2: Mineral wool

3. Extruded polystyrene (XPS) – Moisture-resistant and highly durable.

Extruded polystyrene foam is a synthetic insulation material obtained by extruding polystyrene granules. XPS boards have a smooth surface and a dense fine-cell structure, providing high strength, flexibility, and durability. This material does not absorb water, shrink, or decompose and is resistant to chemicals and microorganisms. XPS is widely used for insulating roofs, facades, floors, foundations, walls, and various engineering structures. It is suitable for both civil and industrial construction.

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Figure 3; Extruded polystyrene material.

4. Vacuum panels – The latest technology with the lowest thermal conductivity coefficient.

These panels utilize ultra-thin fibers as the core material and undergo a wet-laying process. They are characterized by low bulk density, low thermal conductivity, good elasticity, and non-flammability. Vacuum panels have a fine texture, providing a smooth surface and excellent handling properties. They are particularly suitable for applications with space constraints and represent a high-quality thermal insulation material.

Figure 4: Vacuum panels

Discussion:
Key findings regarding energy savings and heat insulation improvement include:

- **Material quality and technology** – While modern materials offer high efficiency, their production costs remain relatively high.
- **Environmental impact** – Some synthetic materials generate higher carbon emissions during production.
- **Construction standards and regulations** – Many countries are implementing strict energy efficiency standards, driving the need for new innovations.
- **Future prospects** – New-generation insulation materials based on biocomposite materials and nanotechnologies are being developed.

Conclusion:
Heat insulation and energy-saving materials play a crucial role in construction. Their application enhances the energy efficiency of buildings and positively impacts the environment. The development and adoption of high-performance, eco-friendly materials remain a pressing issue.

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Therefore, further research on innovative materials and their practical implementation is essential.

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